RESEARCH HIGHLIGHT
Basic Energy Sciences Program
Geosciences Subprogram

Project: Permeability Upscaling Measured on a Block of Berea Sandstone: Results and Interpretations

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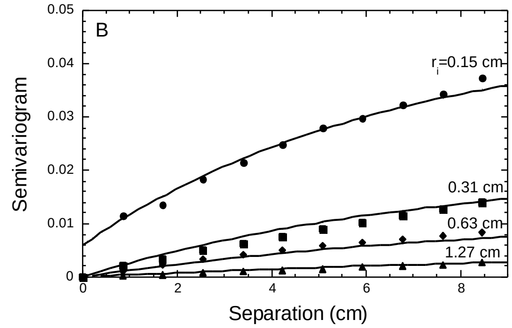
Objectives: There are few data sets, collected under controlled experimental conditions, that clearly document the upscaling of permeability measurements collected from natural geologic materials. Here, we present the results of physical upscaling experiments performed on a block of Berea Sandstone. Using a computer automated minipermeameter test system we measured over 13,000 permeability values with four different sample supports (sample volumes), each subject to the same boundary conditions and flow geometry. To help interpret the measured upscaling we compared the observed trend in the mean permeability to predictions from two published theoretical models based, respectively, on uniform and non-uniform flow assumptions.

Results: Results show the calculated permeability statistics (i.e., permeability maps, semivariograms) to be strongly correlated with the stratified structural features visible in the sandstone sample. Summary statistics calculated from the data show clear and consistent trends with changing sample support (i.e., upscaling), as shown below. Theoretical modeling compared to the measured mean upscaling consistently under predicted the physical data. Discrepancies between the data and models were used to identify the basic controls on the measured permeability upscaling. We found the non-uniform flow imposed by the minipermeameter coupled with permeability anisotropy at the scale of the local support (i.e., smallest sample support for which data are available) to be the primary factors influencing the measured upscaling. The poor fit between the data and the theoretical models results largely from the fact that our local-support permeability data, which we are forced to adopt as point-support (i.e., infinitely small sample support), are inconsistent with the conditions assumed in the models; specifically, in the models the point-support permeability is isotropic and independent of its measurement conditions.

Significance: These data provide rare physical evidence of: 1) permeability upscaling, and 2) the significant influence non-uniform flow can impose on permeability upscaling. Although permeability data are commonly derived from non-uniform flow tests (e.g., permeameters, pump and slug tests), few upscaling models have application under such conditions.

Publication: Tidwell, V.C., and J.L. Wilson, Permeability Upscaling Measured on a Block of Berea



Sandstone: Results and Interpretations, *Mathematical Geology*, 31(7), 749-769, 1999.

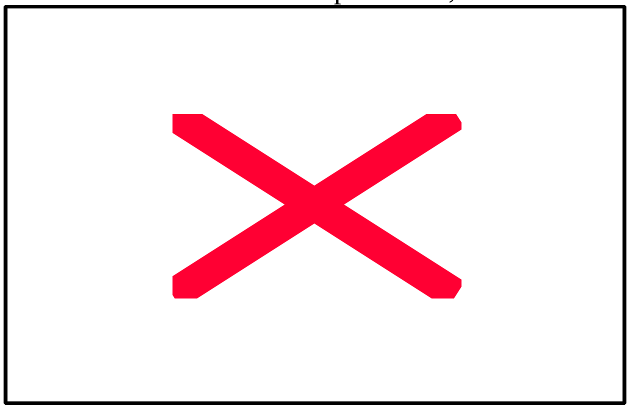


Figure: Upscaling of permeability statistics measured on a block of Berea Sandstone. A) Cumulative distribution functions (CDFs) for the natural-log permeability data sets measured with each of four different-size tip seals. As the tip seal size (i.e., sample support) increases the shape of the CDF changes while the mean increases and the variance decreases. B) Semivariogram transects for the natural-log permeability measured with each of the four different-size tip seals. Transects are oriented parallel to the stratification visible in the sandstone sample. As the tip seal size increases the semivariogram range increases, the sill decreases, while the basic structure remains unchanged.